



NEPAG Report NASA Electronic Parts Assurance Group

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Mars 2020 Perseverance Rover is exploring surface of Mars. The mission, targeted for launch in July/August 2020, takes the next step by not only seeking signs of habitable conditions on Mars in the ancient past, but also searching for signs of past microbial life itself.

Elements of this image furnished by NASA

NEPP – Mission Statement



Provide NASA's **leadership** for developing and maintaining guidance for the **screening, qualification, test**, and reliable use of EEE parts by NASA, in **collaboration** with other government agencies and industry.



NASA Electronic Parts Assurance Group (NEPAG) is a core portion of NEPP

NASA Electronic Parts Assurance Group (NEPAG)

- **NEPAG is about Standards for electronic parts; finding solutions for NASA flight projects/programs; day-to-day parts issues. We are part of Mission Assurance Standards and Capabilities (MASC) Division.**
 - Maintenance
 - ❖ Provide NASA leadership
 - Creation
 - ❖ Infuse New Technology, e.g., Class Y for Space
 - ❖ Address the advances in packaging technology, e.g., newly started task group (TG) on 2.5D/3D devices
 - ❖ Respond to user requests, e.g., a new TG on standard plastic encapsulated microcircuits (PEMs) in Space
 - ❖ Relevant TGs: 3 main and 4 support TGs open
 - Related Activities
 - ❖ Hold telecons
 - NASA Electronic Parts Assurance Group (NEPAG)
 - Government Working Group (GWG)
 - Hybrid Working Group (HWG)
 - ❖ Support Defense Logistics Agency (DLA) audits of supply chain
 - ❖ Partnerships: JEDEC, SAE, Domestic and International space organizations, DLA, GIDEP, others
 - ❖ Standard microcircuits drawing (SMD) review
 - ❖ Outreach (Publish NASA EEE Parts Bulletins; present at meetings)
 - ❖ Learn and Lunch Webinars with the supply chain
 - ❖ Parts issues resolution at JPL. Booklet in progress.
 - ❖ Other as needed

Impact of COVID-19

- **Response to COroNaVirus Disease – 2019, COVID-19 (October 2020 onwards)**

- **Significant Impact**

- ❖ DLA Audits and NASA ESD surveys continued to be on hold
- ❖ DLA 19500 manufacturer qualification group set up a process to perform virtual audits. Was supported by MSFC.

- **No / Minimal impact**

- ❖ NEPAG, GWG, HWG telecons (No impact)
 - NEPAG – NASA Electronic Parts Assurance Group, held every week
 - Led by S. Agarwal, NASA/JPL
 - International, first Wednesday of the month
 - Domestic, every Wednesday rest of the month
 - GWG – Government Working Group, held bi-week
 - Led by K. Laird, NASA/MSFC; Co-Lead: C. Schuler, Navy Crane
 - HWG – Hybrid Working Group, held monthly
 - Led by J. Pandolf, NASA/LaRC
- ❖ Learn@Lunch Webinars (changed to virtual only)
- ❖ NASA Parts Bulletins (No impact)
- ❖ SMD reviews (No impact)
- ❖ JEDEC/SAE meetings (changed to virtual only)
- ❖ Electronic Parts and ESD (Some impact)
- ❖ Conferences/Meetings
 - All Virtual – ESCCON, SPWG, NEPP ETW (NETW)
 - Mixed format – JAXA MEWS
 - NASA Face-to-Screen-to-Face (F2S2F) Parts Meetings
 - Changed to all virtual format



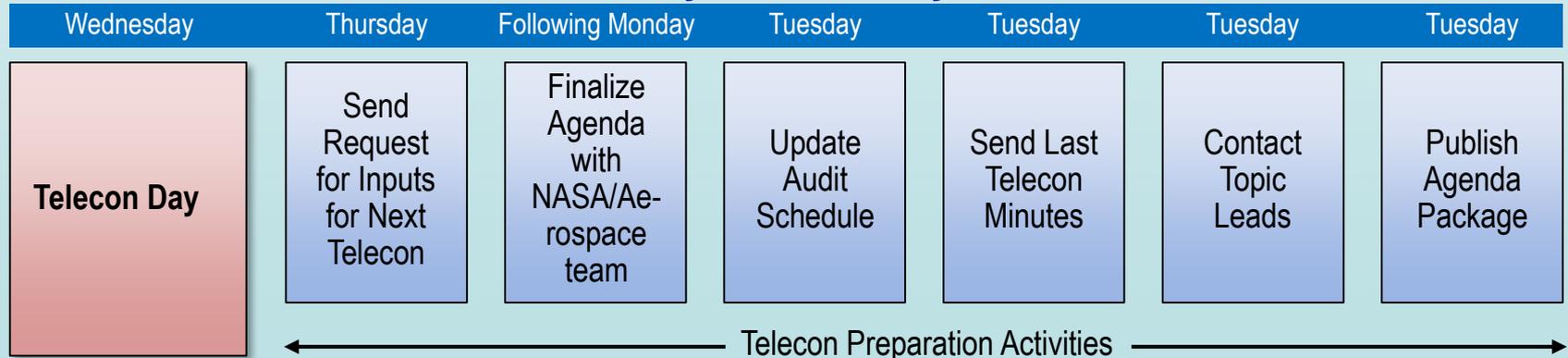
- **Other**

- The 8739-11 document was the subject of a NASA Technical Talk at the SAE CE-12 meeting last month. It was led by P. Majewicz, C. Green and N. Siddiqi.

Telecons

- **NEPAG Telecons** (Core team that sets the weekly agenda: S. Agarwal, B. Brandon, P. Majewicz, J. Pandolf, J. Brusse, K. Laird, L. Harzstark/Aerospace)
 - **Held since 2000, these telecons drive the NEPAG program. The weekly cycle is shown below.**
 - **Typical Telecon Agenda Package contains**
 - ❖ List of items for discussion
 - ❖ DLA audit schedule, SMD review status, Learn@Lunch Webinars, technical meetings, list of items for discussion at next JEDEC/CE-11, CE-12.
 - ***Return on Investment for NASA flight projects***
 - ❖ ***Coordination of parts issues with DLA and the aerospace community***
 - **Q1-Q2 FY21 Status:** Had 14 Domestic and 6 International calls.
 - **Impact of Coronavirus: None**

Weekly Telecon Cycle

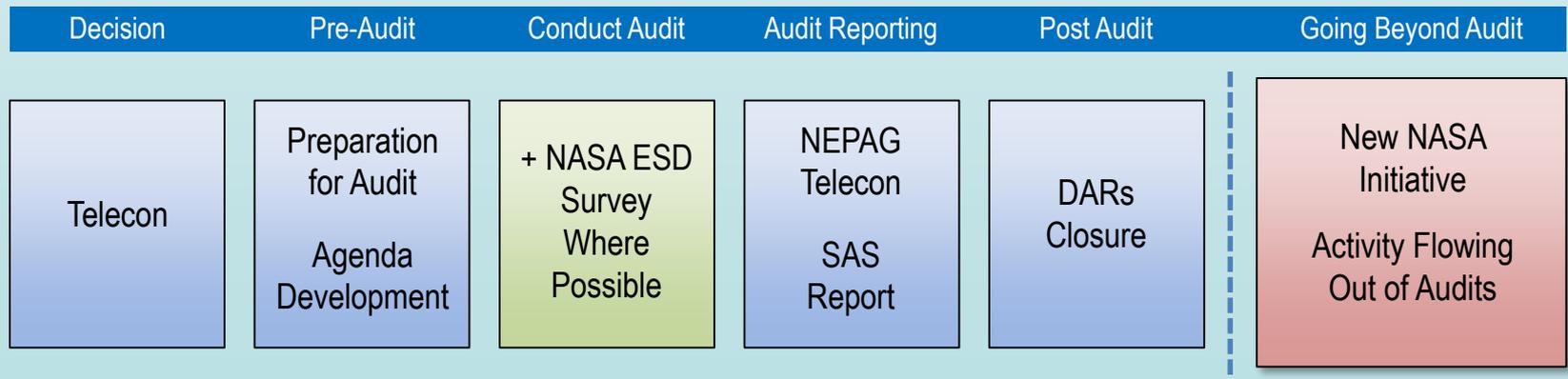


Defense Logistics Agency/Land and Maritime “DLA” Audits

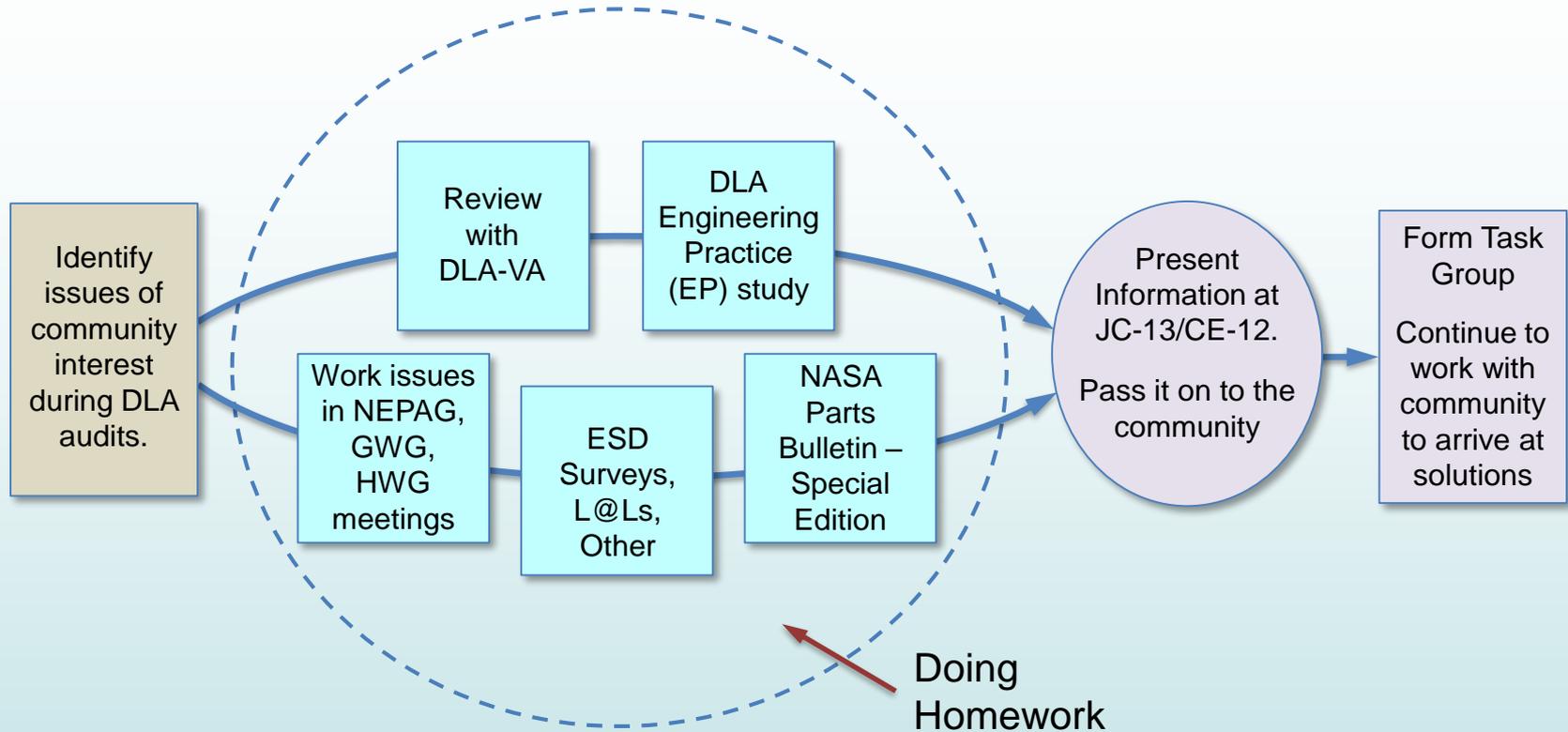
• DLA Audits

- **NASA supports DLA audits as technical experts. Responsibilities divided as follows:**
 - ❖ Passives: Brusse; Hybrids: Panashchenko, Pandolf and Majewicz; PWB: Gutierrez; Discretes: Damron; Connectors: Billig; Test Methods: Laird; Microcircuits: Agarwal
- **Reports:** Verbal reports given on NEPAG telecons. SAS (Supplier Assessment System) report sent to M. O’Bryan at GSFC for posting on database at JSC.
- **Return on investment for NASA flight projects**
 - ❖ **Ensure that NASA inputs are incorporated into part manufacturers’ processes**
 - ❖ **Review and resolve any parts issues with the manufacturers while on audit**
 - ❖ **Develop contacts for future needs (e.g., finding critical parts)**
- **FY21 Status:** NASA participated in 2 virtual audits so far. Due to novel Corona virus crisis, DLA has postponed all travel until further notice.
- **Impact of Coronavirus: Yes, major impact.**

Audit Process



Taking Audit Findings a Step Further!



- Bring general awareness (Via NASA Bulletins, Surveys, Learn and Lunch webinars with supply chain, presentations at meetings)
- Work with DLA to conduct engineering practice (EP) study
- Generate a basic proposal and related information so the potential task group (TG) has a strong starting point.
- This path has **saved time** in working on major issues.

Standard Microcircuit Drawings (SMDs) Review

- **SMDs Review/Standards Activity** (All centers with NEPAG Partners)
 - **NASA Specific Goals**
 - ❖ Provide comments to DLA-VA on newly drafted SMDs.
 - 10 day comment period
 - ❖ As part of QA (Qualifying Activity), review qualification data on new microcircuits
 - Several telecons are held with Aerospace, DLA and manufacturer
 - **Return on investment for NASA flight projects**
 - ❖ **NASA gets to bring in their perspective on standards issues. JC-13/CE-11/CE-12 represent a big investment on standards activity for NEPAG. NASA works with the community on standards issues.**
 - **Impact of Coronavirus: No impact. Continued document reviews.**

JEDEC JC-13 / SAE CE-11, CE-12

Support to JC-13/CE-11/CE-12

- **Work with/lead JC-13/CE-11/CE-12 communities to develop/maintain standards**
 - ❖ Vice-chair CE-12
 - ❖ Member Executive Council
 - ❖ Chair CE-11/CE-12 Space Subcommittee
 - ❖ Take CE-12 meeting notes
 - ❖ Present status update, e.g., Class Y
 - ❖ Actively support various task group meetings

- **The May 2021 meeting was virtual**

- **CE-12 Leadership**
 - ❖ The current Chair will step down after January 2022
 - ❖ NASA has a big investment in these meetings
 - ❖ Agencies and the primes have to develop a succession plan

- **Return on investment: JC-13/CE-11/CE-12 represent a big investment on standards activity for NEPAG. NASA works with the community on standards issues.**

- **Future Meeting**
 - ❖ The September 2021 meeting will also be virtual.

Electronic Parts and ElectroStatic Discharge (ESD)

- **Electronic Parts and ESD** (N. Ovee, M. Doe, M. Nelson, M. Han, E. Kim, S. Agarwal)
 - **NASA Specific Goals**
 - ❖ During the DLA audits of the supply chain, we realized that there were practically no requirements for ESD. Need to update standards.
 - ❖ Microcircuit pin count has increased significantly (e.g., Vertex FPGAs have 1752 columns). Current qualification standards were developed years ago with pin counts in the twenties. Applying these old device testing standards to modern high-pin count products can cause severe problems (e.g., testing times increase dramatically).
 - ❖ Furthermore, microcircuit part production is no longer under one roof, but landscape of supply chain is multiple specialty houses.
 - ❖ Costs can not be ignored – per unit price for advanced devices is approaching \$200k. ESD mitigation costs are minute compared to the device unit costs.
 - ❖ ESD surveys/audits of COTS hardware/parts suppliers should be mandatory.
 - ❖ Mitigation strategies include ESD surveys, observations during audits, standards updates & outreach to the military & space communities. There is always a latency risk from ESD.
 - ❖ Outreach: NASA has published extensively on this subject (released 4 Parts Bulletins). We plan to publish a guideline document, and will continue to report at conferences.
 - **Return on investment for NASA flight projects**
 - ❖ ***NASA initiated and led the Electronic Parts and ESD effort. We provide updates at JC-13 TG, SPWG and ETW meetings.***
 - ❖ ***Supply chain is deriving benefits from NASA ESD Surveys.***
 - **FY21 Status Report:** Presented at JC-13 TG meeting in January. Conducting limited testing per human body model (HBM). Released NASA Bulletin on ESD testing.
 - **Impact of Coronavirus: Partial – no NASA ESD surveys. Continued testing and meetings.**

NASA EEE Parts Bulletins

- **EEE Parts Bulletins** (All centers with NEPAG Partners)
 - **NASA Specific Goals**
 - ❖ An outreach activity since 2005
 - ❖ The EEE Parts Bulletin is a 4-10 page newsletter with articles of interest to the community.
 - Goal is to issue one to four times per year
 - Distribution is to few thousand individuals in the user/supplier communities
 - ***Return on investment for NASA flight projects. A unique NASA outreach activity which is appreciated by the space community around the world.***
 - **FY21 Status Report:** Released bulletins on non-hermetics, ESD testing, KGD.
 - **Impact of coronavirus: None**

Learn at Lunch (L@L) Webinars with Supply Chain

- **NASA L@L Webinars**

- **NASA Specific Goals**

- ❖ Supply chain is asked to present technical descriptions of existing, new products under development, and their near-term vision. Marketing pitches are kept to a minimum.
- ❖ Usually held on Wednesdays at lunch time
- ❖ Audience: All NASA centers and space community. On-site and remote participation.
- ❖ Representatives from Standards organizations (e.g., DLA and ESA) have also presented on status/trends of EEE parts specifications.
- ❖ We gather manufacturer data on status of parts functions, e.g., A/D Converters.
- ❖ The supply chain likes these meetings because they get to meet their customers (hardware designers, parts engineers), see the campus, etc. Separate meetings are scheduled to review any on-going issues.
- ❖ The support is provided by JPL Component Engineering and Assurance Office (CEAO).
 - Management: M. Mojarradi, J. Bonnell, N. Sucher
 - Organizing Team: B. Brodtkin, N. Ovee, S. Agarwal

- ***Return on investment for NASA flight projects***

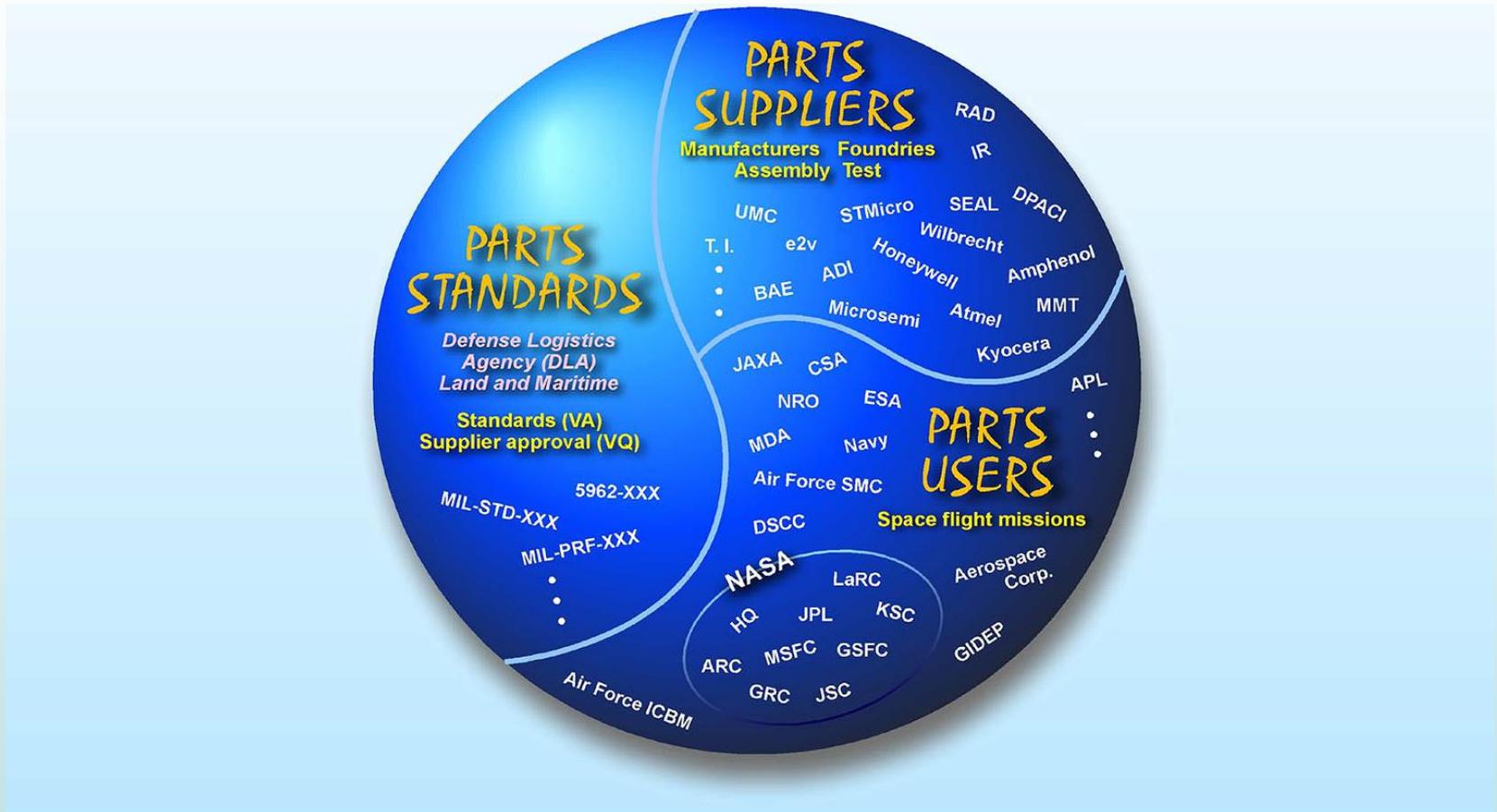
- ❖ ***These Webinars give NASA (and other user community) an opportunity to get to know our supply chain.***

- **FY21 Status:** Organized 14 Webinars. All were virtual.

- **Impact of coronavirus:** Limited – supplier are no longer able to come on campus for face-to-face meetings with designers/parts engineers.

Space Parts World

NEPAG helps to Develop/Maintain Standards for Electronic Parts

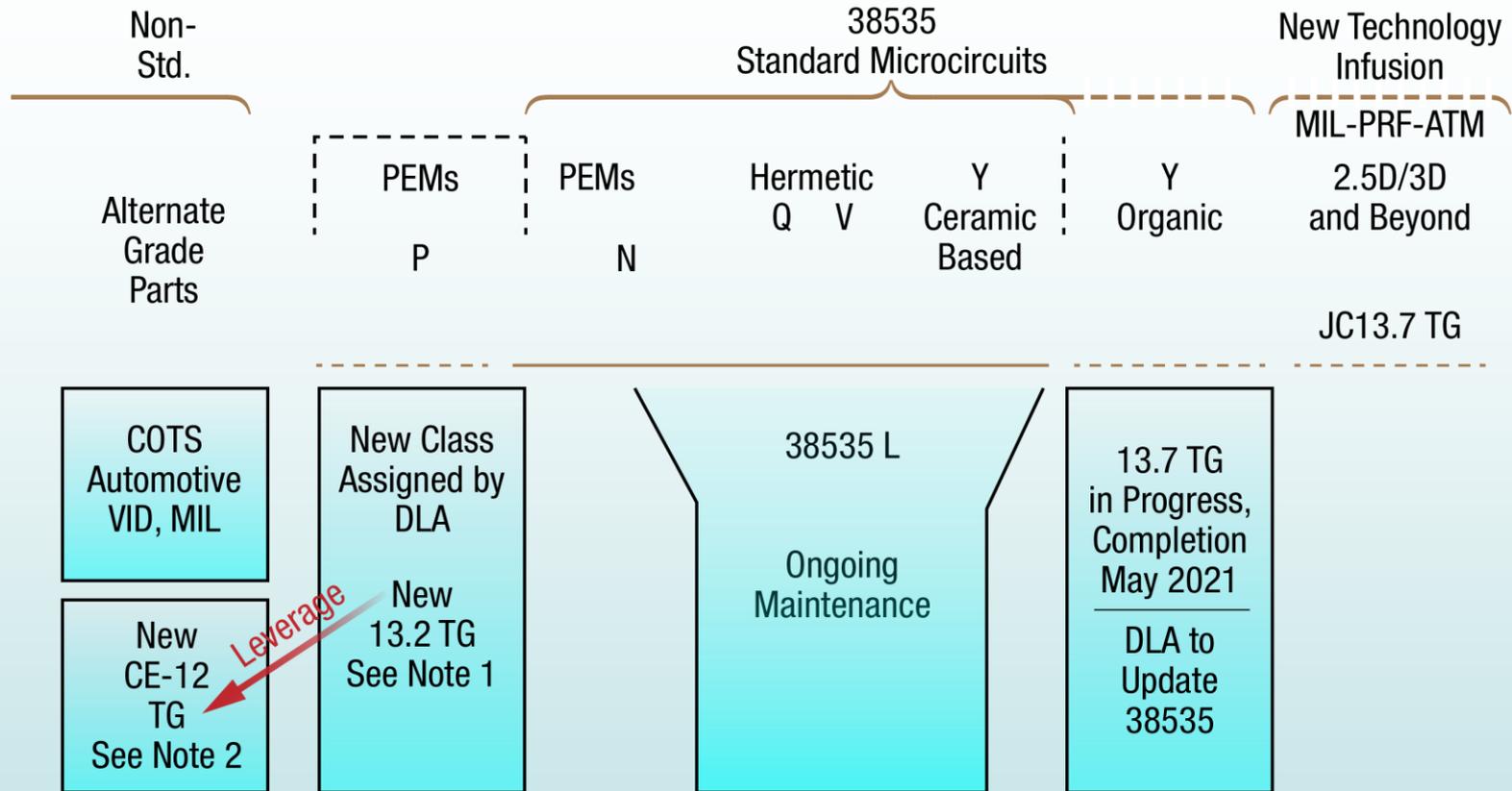


The parts users and standards organizations work with suppliers to ensure availability of standard parts for NASA, DoD, and others. **For Space microcircuits, DLA, NASA/JPL (S. Agarwal*) and the U.S. Air Force / Aerospace Corp. (L. Harzstark) form the Qualifying Activity (QA).**

*Also Systems, Standards and Technology Council (SSTC) G-12 Vice-Chair; Chair, Space Subcommittee.

Options for Microcircuits

Rev. D, 6-10-21



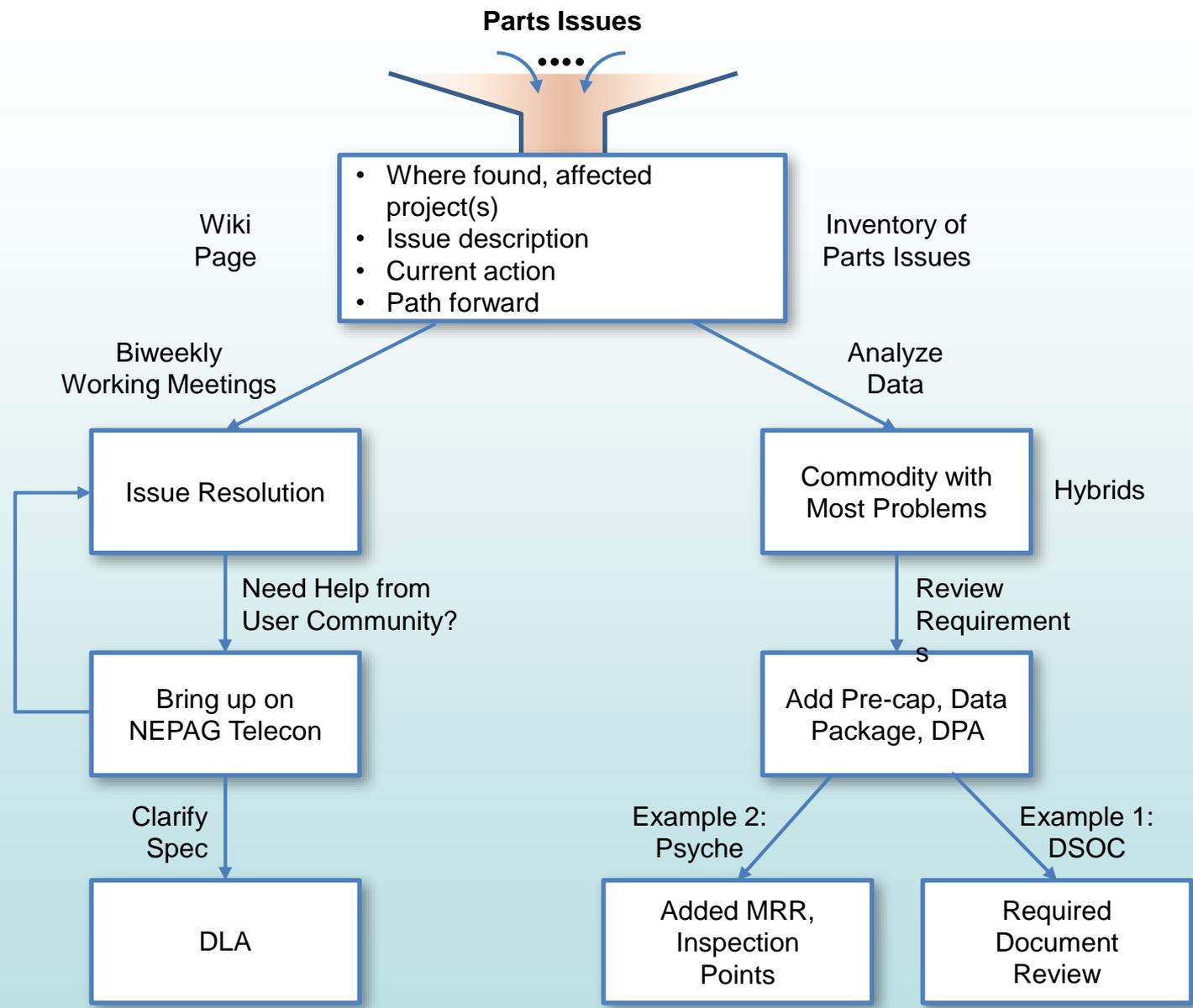
- Note 1: Standard PEMs for Space (QMLP) initiative using SAE AS6294 as baseline. Supported by NASA Parts Bulletins on PEMs.
- Note 2: For alternate grade microcircuits, follow the activity in 13.2 TG to avoid any duplication of effort.
- Note 3: ATM = Advanced Technology Microcircuits. Supported by NASA parts bulletin on KGD.
- Note 4: VID = Vendor Item Drawing. Contact DLA for latest information.
- Note 5: ***The boundaries separating various classes/grades must be clearly defined - future outreach activity.***

NEPAG Activities (Contd.)

• Other Significant Activities

- **NASA Parts Management Meetings**
 - ❖ Held two times a year. The next meeting is June 21-22, will be virtual. (B. Bodkin, S. Douglas)
- **Component Engineering and Assurance Office (JPL Office 514)**
 - ❖ S. Agarwal Chairs the bi-weekly meetings on path to resolve flight parts issues.
 - **Wiki Page.** A wiki page has been created to simplify the effort.
 - **Booklet.** A booklet summarizing our experiences for the first 10 issues is being compiled. (R. Brandon, C. Marie-Peterson)
 - **NEPAG Connection.** Used NEPAG, GWG and HWG telecons as a resource.
 - **Hybrid DPAs and FAs.** Since hybrids had the most problems, created a telework task to review their DPAs and FAs. (S. Gore, T. Apple, J. Martinez, R. Evans)
 - **MIL-STD-883/Test Method 2012 Review.** There were questions raised on third party disposition of hybrid X-ray results. A telework task was opened to review the radiography test method for any ambiguities. This work was submitted to the HQ. The comments were also passed on to the GWG for further discussion and recommendations. (J. Bescup)
- **Impact of Coronavirus**
 - ❖ **DLA Audits and NASA ESD Surveys were postponed**
 - A telework task was created to make **supply chain assessment**. The progress was reported on NEPAG domestic and international telecons. (I. Khan, S. Grover, L. Boyle)

Path to Parts Issues Resolution



DLA: Defense Logistics Agency; DPA: destructive physical analysis ; DSOC: Deep Space Operations Center; MRR: Manufacturing Readiness Review.

Next Step: A “Parts Issues Booklet”

- The wiki page contains over 125 parts issues
 - How to use this data/disseminate this experience base to others while safeguarding information that might be vendor/JPL project– proprietary
 - Concept of a booklet evolved
- Create a booklet that
 - Captures the technical essence (summary) of each parts issue
 - In consultation with parts SMEs
- Share with NASA centers

BACK - UP

NEPAG Activities in Q1-Q2FY21



Activity	Q1	Q2	Q3	Q4	Total
*FY21					
DLA Audits Supported	**	**			0
NASA ESD Surveys	**	**			0
Standard Microcircuit Drawings (SMDs)	4	2			6
Domestic Telecons (Average Attendance)	7 (42)	7 (39)			14 (41)
International Telecons (Average Attendance)	3 (35)	3 (37)			6 (36)
NASA EEE Parts Bulletins	1	1			2
Learn @ Lunch Webinars	4	5			9
Meetings/Conferences (Agarwal)	1	1			2
JPL Inputs on INST Update		Done 3-29-21			
*Supported by: B. Bodkin, A. Hanelli, S. Khandker, N. Ovee, D. Gallagher, M. Han, R. Swain, K. Munsell, J. Martinez, C. Ashbury, A. Azizi, R. Evans, I. Khan, L. Boyle, S. Grover, M. Do, P. Spence, T. Gutierrez. **Postponed					

NEPAG Activities in FY19 (No Covid) vs FY20 (Covid)

(COVID-19 impacted travel activities, such as Audits/Surveys. Meetings were changed to virtual format)

Activity	Q1	Q2	Q3	Q4	Total
FY19 (No COVID)					
DLA Audits Supported	5	2	7	12	26
NASA ESD Surveys	1	1	1		3
Standard Microcircuit Drawings (SMDs) & Slash Sheets	5	7	2	1	15
Domestic Telecons (Average Attendance)	6 (30)	10 (32)	5 (33)	8 (32)	29 (32)
Intl Telecons (Average Attendance)	2 (27)	2 (28)	3 (29)	2 (27)	9 (28)
<i>EEE Parts Bulletin</i>			1		1
Learn@Lunch Webinars	2	3	5	4	14
Meetings/Conferences (Agarwal)	1	1	3	2	7
FY20 (COVID from Q2 to FY End)					
DLA Audits Supported	5	3	**	**	8
NASA ESD Surveys	**	**	**	**	**
Standard Microcircuit Drawings (SMDs) & Slash Sheets	2	5	9	4	20
Domestic Telecons (Average Attendance)	7 (32)	9 (39)	9 (49)	8 (51)	33 (43)
Intl Telecons (Average Attendance)	3 (29)	2 (29)	3 (40)	2 (40)	10 (34)
<i>EEE Parts Bulletin</i>			1	*1	1+*1
Learn@Lunch Webinars	4	8	2	5	19
Meetings/Conferences (Agarwal)	4	2***	1***	1***	7

- * 1 Bulletin in review by NASA centers.
- ** Postponed ***Virtual



NASA EEE Parts Bulletin, May 15, 2020



October 2019–March 2020 • Volume 11, Issue 1,¹ May 15, 2020

Non-Hermetic and Plastic-Encapsulated Microcircuits

The mission assurance organizations at NASA have supported many large and small space missions and programs over the years. Today that spectrum has expanded, ranging from flagship missions such as Mars 2020 with its Perseverance Rover, Europa Clipper, and the proposed Europa Lander, to SmallSats/CubeSats such as the Temporal Experiment for Storms and Tropical Systems—Demonstration (TEMPEST-D) and Mars Cube One (MarCO). Plastic-encapsulated microcircuits (PEMs) have become more attractive since leading-edge alternatives are not available as space-qualified products. PEMs generally have smaller footprints and are lighter than the ceramic packages used in space-qualified products [1]. As the demand and use of non-hermetic and plastic-encapsulated microcircuits for space has increased, the scope of what future missions are capable of has also widened. This changing climate related to EEE parts selection presents new challenges for NASA, which—as always—holds the success of every mission paramount.

Growing Use of NASA SmallSats and CubeSats

Due to the need for low-cost communications satellites and new businesses evolving around Earth-observation services, there's been an increased interest in the use of CubeSats and SmallSats. Many NASA centers have been involved in developing and flying CubeSats and SmallSats, working together with multiple universities and industry partners. These undertakings require new product solutions for smaller, lighter, and lower-cost spacecraft, which cannot be produced using traditional space-qualified electronic parts.

The reliability and radiation requirements for CubeSats and SmallSats are significantly lower than for larger spacecraft because these smaller satellites operate mainly in low Earth or geosynchronous orbits (LEO or GEO, as opposed to deep space) and for relatively short periods. Radiation-hardened, high-reliability, space-grade parts are often too expensive for such missions and do not match well with their requirements.

There are a few notable exceptions to the usual use of CubeSats, particularly MarCO-A and MarCO-B, which were the first CubeSats to fly to deep space, where they successfully supported the Interior Exploration Using

Seismic Investigations, Geodesy, and Heat Transport (InSight) mission by relaying data to Earth from Mars during the entry, descent and landing stage (Figure 1). MarCO successfully demonstrated a "bring-your-own" communications-relay option for use by future Mars missions in the critical few minutes between Martian atmospheric entry and touchdown. Further, by verifying that CubeSats are a viable technology for interplanetary missions, and feasible on a short development timeline, this technology demonstration could lead to many other applications to explore and study our solar system.

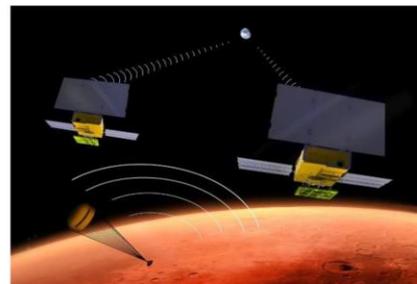


Figure 1. MarCO accompanying the InSight Mars lander and relaying data to Earth as it landed on Mars.

¹ The EEE Parts Bulletin was not published in fiscal year 2019 (FY19). The two issues of Volume 10 were published in FY18.

NASA EEE Parts Bulletin

Special Edition: Non-Hermetic and Plastic-Encapsulated Microcircuits, Part 2

URS296932, CL#20-6169



Volume 12, Issue 1, October 20, 2020 Non-Hermetic and Plastic-Encapsulated Microcircuits, Part 2

The mission assurance organizations at NASA have supported many large and small space missions and programs over the years. Today, that spectrum has expanded, ranging from flagship missions such as Mars 2020 with its Perseverance Rover, Europa Clipper, and the proposed Europa Lander, to SmallSats/CubeSats such as the Temporal Experiment for Storms and Tropical Systems—Demonstration (TEMPEST-D) and Mars Cube One (MarCO). Plastic-encapsulated microcircuits (PEMs) have become more attractive since leading-edge alternatives are not available as space-qualified products. PEMs generally have smaller footprints and are lighter than the ceramic packages used in space-qualified products [1]. As the demand for and use of non-hermetic and plastic-encapsulated microcircuits for space has increased, the scope of what future missions are capable of has also widened. This changing climate of EEE parts selection presents new challenges for NASA, which—as always—holds the success of every mission paramount. In this second issue devoted to non-hermetic and plastic-encapsulated microcircuits, we discuss more manufacturers' PEMs flows, and introduce the AS6294/1 aerospace standard document on "Requirements for Plastic Encapsulated Microcircuits in Space Applications."

Aerospace Standard AS6294/1

Due to the need for low-cost communications satellites and for new businesses evolving around Earth-observation services, there's been increased interest in the use of CubeSats and SmallSats for such missions. Many NASA centers have been involved in developing and flying CubeSats and SmallSats, working with multiple universities and industry partners. These undertakings require new product solutions for smaller, lighter, and lower-cost spacecraft that cannot be produced using traditional space-qualified products.

In 2017, a subcommittee of SAE International's Group 12 (G12) was created to standardize a PEMs flow and to address a possible future extension of the Qualified Manufacturer List (QML) system to include PEMs for space. Considerable effort was put into developing a PEMs flow for space applications, documented in SAE Aerospace Standard AS6294/1, issued in November 2017, titled "Requirements for Plastic Encapsulated Microcircuits in Space Applications." The "1" version was directed at space applications, the "2" version at

terrestrial applications. SAE AS6294/1 pulled information from many Marshall Space Flight Center (MSFC), Goddard Space Flight Center (GSFC), and SAE standards applicable to NASA—namely, MSFC-STD-3012, GSFC EEE-INST-002, GSFC PEMS-INST-001, and SAE S58-001—as well as reviews of multiple industry practices.

AS6294/1 defines the requirements for screening, qualification, and lot-acceptance testing for use of PEMs in space flight applications. The level of testing is dependent on the risk approach, the application, and the reliability and radiation requirements of the mission. However, AS6294/1 contains only requirements that meet the highest known reliability for space applications. The document also addresses many concerns associated with PEMs, such as narrower operating temperature ranges and greater susceptibility to infant mortality and moisture absorption than space-grade products have [2]. AS6294/1 starts with device characterization for parts that don't meet space requirements. The characterization step includes the initial investigations needed to understand the details of the technology used in a PEM product [2]. This is crucial when the

¹ This issue is a follow-on to Volume 11, Issue 1, released May 15, 2020: "Non-Hermetic and Plastic Encapsulated Microcircuits."

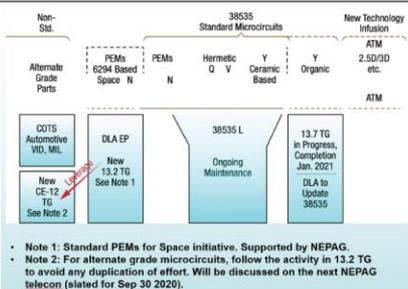
Once the task group based on J13.2 completes its work, a new proposed TG will be formed to support alternate-grade microcircuits. The work performed by the J13.2

evaluated the of a PEM in a nding on the h the manu- include con- volution, is analysis, brant Infor- workmanship, d to a PEM ata gathered hing and lot- ation steps

d to all flight nd inspecting checks the screening test in AS6294/1 nd functional tests, a percent value is calculated with a

performed on parts that pass n step includes life-testing, temperatures, temperature d by failure analysis for any s have met all requirements are cleared for flight.

ver become a standard QML immediately adopted in its nufacturers, who offer their that in AS6294/1. With the the use of standard plastic s, the space community ment and take a renewed a standard PEMs flow for scussed in domestic and nic Parts Assurance Group t Working Group (GWG) open a new task group was J13.2 session, in which task group from industry WG support. The task group mantha Williams of Texas leon of Boeing.



- Note 1: Standard PEMs for Space initiative. Supported by NEPAG.
- Note 2: For alternate grade microcircuits, follow the activity in 13.2 TG to avoid any duplication of effort. Will be discussed on the next NEPAG telecon (slated for Sep 30 2020).

Figure 1. Options for standard, nonstandard, and new-technology microcircuits.

TG will be heavily leveraged in order to avoid any duplication of effort. See Figure 1 for details on current and future options for nonstandard, standard, and new-technology microcircuits.

Manufacturer Solutions for Non-Hermetic and Plastic-Encapsulated Microcircuits

Historically, satellite programs have used space-grade, hermetically sealed, QML-V (space) and QML-Q (military) qualified components for enhanced reliability and radiation hardness. With the emergence of "commercial space," there has been increased interest in using PEMs in space for a variety of reasons. Countering the concerns cited above—narrow operating temperature ranges and susceptibility to infant mortality and moisture absorption [2]—are certain advantages of PEMs over most space-grade hermetically sealed microcircuits: lower cost and weight, more advanced performance, lower power consumption, and smaller overall package size.

With this new growing trend in the market, an increasing number of suppliers now offer a wide range of enhanced plastic product solutions depending on quality, reliability, radiation, and cost. Not all of these product lines follow a consolidated test flow, and all depend on the specific tailoring that each manufacturer makes to them. Hopefully, in the near future, the industry will lean

- Sub-group 1b - DPA/FA
- Sub-group 2 - Biased HAST
- Sub-group 2 - Unbiased HAST

mon flow that will be produced

develops and manufactures is for healthcare, life sciences, defense, security, and industrial ceramic and plastic, hermetic ts, tested to various flows, Q, QML-Y (non-hermetic for more. Table 1 shows Teledyne nd qualification flows and the they use [3].

space applications, sub-QML e arrays (FPGAs) aimed at n traditional QML components shelf (COTS) components, the radiation or reliability data. For ns and constellations of small tringent cost and schedule PGAs are the optimal solutions, tolerance of QML components flight heritage, which permits

reduced screening requirements, resulting in reduced cost and lead times.

Microchip also provides two space plastic flows: HiRel plastic radiation-tolerant (HP) and 8-lead plastic small-outline (SN). The HP flow is for low-cost and high-volume requirements, typically meeting low-Earth-orbit (LEO) constellations' needs. The SN flow provides a higher screening level, including wafer lot acceptance, serialization, 100% thermal cycling, 100% burn-in, and PDA. These flows apply to both rad-hard-by-design and rad-tolerant products. Products made to these flows (SN, HP) meet qualification levels compliant with automotive requirements (AEC-Q100), with the SN flow based on AS6294/1. See Table 2 for more details on the screening and qualification flows for Microchip HP and SN devices [4].

Micros offers an extensive array of COTS components—both hermetic and plastic—including a wide selection of power modules and small-signal discretes. They also stock a wide range of unscreened plastic products, including an assortment of integrated PEM (iPEM) memory devices that have been tested to selected high-reliability performance levels. In their Retail+ products line, Micros provides customers with industry-leading

Table 1. Teledyne e2v has various plastic non-hermetic test flows.

Benefits	TELEDYNE e2v Everywhereyoulook			
	Level 1 EEE-INST-002 / PEM-INST-001	Level 2 NASA level	Level 3 Enhanced	-EP Int. procedure
Specification reference-->>	✓	✓	✓	✓
Assembly and test site, one BOM datalog	✓	✓	✓	✓
Condition/method				
MIL-STD-883 TM1010 cond. B (55/125°C) or C (-65/150°C)	20 cys - cond. B20 cys - cond. B20 cys - cond. B10 cys - cond. C	✓	✓	✓
MIL-STD-883 TM2012	✓	✓	✓	✓
Radiate				
MIL-STD-883 TM1015 cond. D (125°C)	240 hrs	160 hrs	160 hrs	160 hrs
MIL-STD-883 TM1015 conds. A, B or C (125°C)	120 hrs	✓	✓	✓
Electricals (weel)				
Ambient temperature post dynamic	5%	10%	10%	5%
Per device specification (55/125°C)	✓	✓	✓	✓
Per device specification (25°C)	✓	✓	✓	✓
SA) Condition/method				
TID & SEE				
PEM-INST-001	Per rad tests	Per rad tests	Per rad tests	
Moisture soak/Reflow simulation	22	22		
MIL-STD-883 TM1005 / D / 125°C	32	32	17	
MIL-STD-883 TM1010 / B - DPA	1500 hrs / 22	1000 hrs / 22	500 hrs / 10	
PEM-INST-001	500 cys / 22	200 cys / 22	100 cys / 10	
EEE-INST-002 on 5 parts	22	22		
JESD22-A110 96 hrs / 130°C / 85% RH	✓	✓		
JESD22-A118 / A / 96 hrs / 130°C / 85% RH	10			
		10	7	

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Special Edition: Comparison of Test Methods for Human Body Model (HBM) Electrostatic Discharge (ESD)

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Special Edition: Comparison of Test Methods for Human Body Model (HBM) Electrostatic Discharge (ESD)

Damage from ESD is a cause of major costs to the microcircuit industry in terms of time, money, and mission risk. The *EEE Parts Bulletin* has released four special issues on ESD [1]–[4]. The first issue, in 2016, stressed the need to upgrade specifications related to ESD and suggested improved ESD practices wherever parts are manufactured, stored, or prepared for shipment. The second ESD special issue, in 2017, focused on a parts failure investigation that ultimately identified ESD as the most likely cause of the failure. The 2017 special issue also included an important reminder about regular ESD testing. The third issue, in 2018, provided an example demonstrating the importance of maintaining ESD discipline and high-level risk analysis related to ESD. The fourth issue, later in 2018, was a compendium of the previous three special issues and included an overall updated view of the subject matter.

The current special issue focuses on one specific aspect of ESD damage that is caused by the human body during parts handling. The susceptibility of electronic devices to such damage is characterized by the human body model (HBM). For illustration, the magnitude of electrostatic voltage built up on a chip under different handling means and relative humidity (RH) conditions is shown in **Table 1** [1]. A microcircuit device exposed to an ESD event induced by contact with a human body can easily experience an electrostatic voltage attack in the kilovolt range. Thus, a better understanding of HBM ESD events is warranted. In this issue of the *EEE Parts Bulletin*, we report on independent experimental evaluations of two popular HBM-specific test methods: MIL-STD-883 Test Method 3015.7 [5] and JEDEC JS001-2017 [6]. Similar to the latter, the Automotive Electronics Council (AEC) HBM test method is also included for reference. For a fair and straightforward comparison, a chosen microcircuit chip was subjected to HBM zaps under MIL-STD-883 and JEDEC/AEC conditions, respectively.

HBM Test Standards

A good overview of HBM test standards was presented in the first *EEE Parts Bulletin* special issue on ESD [1]. In this special issue, we compare and evaluate three popular HBM test standards:

1. MIL-STD-883 Test Method 3015.7 (abbreviated MIL-STD-883) [5]
2. JEDEC JS001-2017 (based on JESD22-A114, abbreviated JEDEC-JS001) [6], [7]
3. AEC-Q200-002 REV-B (abbreviated AEC-Q200) [8]

In the following sections, test methods and classifications for these three test standards are extracted from their respective specification documents. The test methods and classifications are summarized and compared in **Table 5**. There are many similarities between JEDEC-JS001 and AEC-Q200, so the primary focus of the comparison was between MIL-STD-883 and JEDEC-JS001.

Table 1. Voltages experienced by electronic devices exposed to various HBM-ESD events [1].

Means of Static Generation	Electrostatic Voltages	
	10–20% RH	65–90% RH
Walking across carpet	35,000	1,500
Walking over vinyl floor	12,000	250
Worker at bench	6,000	100
Vinyl envelopes for work instructions	7,000	600
Common poly bag picked up from bench	20,000	1,200
Work chair padded with polyurethane foam	18,000	1,500

Method 3015.7

Sample of devices shall be ESD failure threshold using 2 kV, and 4 kV, as a be tested using three pulses with a minimum of the pulses.

883 are shown in **Table 2**.

reshold classifications for HBM MIL-STD-883.

Voltage Threshold
0 to 1,999 volts
2,000 to 3,999 volts
4,000 volts and above

Sample of three devices for characterized for the device recommended voltage steps 1 kV, 2 kV, 4 kV, and 8 kV

is shall be stressed at one five and one negative pulse seconds between pulses, and should be used if the vulnerable to cumulative

001 are shown in **Table 3**.

reshold classifications for HBM JEDEC-JS001.

Voltage Threshold
0 to 49 volts
50 to 124 volts
125 to 249 volts
250 to 499 volts
500 to 999 volts
1,000 to 1,999 volts
2,000 to 3,999 volts
4,000 to 7,999 volts
8,000 volts and above

AEC-Q200-002 REV-B

Test Method

AEC-Q200 stipulates: Each sample group shall be composed of 15 components (five voltage levels with three parts per voltage level) and tested using a direct contact discharge probe at one voltage level, at steps of 500 V, 1 kV, 2 kV, 4 kV, and 8 kV, or using an air discharge probe at 25 kV. Two discharges shall be applied to each pin under test within a sample group and at each stress voltage level, one with a positive polarity and one with a negative polarity.

Classifications

Classifications per AEC-Q200 are shown in **Table 4**.

Table 4. Device ESD failure threshold classifications for HBM based on AEC-Q200.

Classification	Voltage Threshold
Class 1A	0 to 500 volts (DC)
Class 1B	500 to 999 volts (DC)
Class 1C	1,000 to 1,999 volts (DC)
Class 2	2,000 to 3,999 volts (DC)
Class 3	4,000 to 5,999 volts (DC)
Class 4	6,000 to 7,999 volts (DC)
Class 5A	8,000 volts (DC) to 11,999 volts (AD)
Class 5B	12,000 to 15,999 volts (AD)
Class 5C	16,000 to 24,999 volts (AD)
Class 6	25,000 volts (AD) and above

DC = direct contact discharge; AD = air discharge.

The main differences among MIL-STD-883, JEDEC-JS001, and AEC-Q200 test methods and classifications are summarized in **Table 5**.

Table 5. Comparison of MIL-STD-883, JEDEC, and AEC test methods and classifications.

Item	MIL-STD-883	JEDEC-JS001	AEC-Q200
Sample Size	Not specified	Three	Three
First Pulse	500 V	50 V	500 V
Pulses per Zap	3 -ve pulses followed by 3 -ve pulses	1 -ve pulse followed by 1 -ve pulse	1 -ve pulse followed by 1 -ve pulse
Timing Interval between Pulses (min.)	1 second	0.3 second	Not specified
Classifications	Three main groups (1,2,3)	Four main groups (0,1,2,3) and three subgroups (Q20A/C/B, 1A/1B/1C, 3A/3B)	Six main groups (1,2,3,4,5,6) and two subgroups (1A/1B/1C & 5A/5B/5C)

Results

UT) selected for this digital driver fabricated using a proprietary metal-oxide-semiconductor technology. This is a common NASA Jet Propulsion All of the DUT parts were date/lot code and tested by the same test procedure and was based on a two-terminal terminal was always latching system (VSS) while the led to the specific test pin of the pins floated. Proper HBM-ations were also performed xperiment.

MIL-STD-883 and JEDEC-JS001

led on this octal driver chip using the following test procedures of JEDEC-JS001 methods. Experimental results and as conducted under “stop- can conclude that the led after the 250-V step per JS001 classifications. The failure 15% tolerance in measured d post-zapped two-terminal acterization.

at HBM trial (250-V pulse step).

Results
Three parts failed after 250 V
Two parts failed after 250 V
One part failed after 500 V

883

is then designed with smaller itage step of 50 V with 100-V uent zaps: 50 V, 100 V, 200 V. results of the second trial-run TD-883. Two parts (M1 and HBM ESD failures over a HBM showed that it could zaps across all its pins. Another s showed in **Table 6** is that

Pins 1–9 of the three parts consistently failed after the HBM zaps.

Table 7. MIL-STD 883–based test results.

SN M1	Pins	50V	100V	200V	300V
1	Failed	NA	NA	NA	NA
2	Failed	NA	NA	NA	NA
3	Failed	NA	NA	NA	NA
4	Failed	NA	NA	NA	NA
5	Failed	NA	NA	NA	NA
6	Failed	NA	NA	NA	NA
7	Failed	NA	NA	NA	NA
8	Failed	NA	NA	NA	NA
9	Pass	NA	NA	NA	NA
11	Pass	NA	NA	NA	NA
12	Pass	NA	NA	NA	NA
13	Pass	NA	NA	NA	NA
14	Failed	NA	NA	NA	NA
15	Pass	NA	NA	NA	NA
16	Failed	NA	NA	NA	NA
17	Failed	NA	NA	NA	NA
18	Pass	NA	NA	NA	NA
19	Pass	NA	NA	NA	NA
20	Failed	NA	NA	NA	NA

SN M2

Pins	50V	100V	200V	300V
1	Failed	NA	NA	NA
2	Pass	NA	NA	NA
3	Failed	NA	NA	NA
4	Failed	NA	NA	NA
5	Failed	NA	NA	NA
6	Failed	NA	NA	NA
7	Failed	NA	NA	NA
8	Failed	NA	NA	NA
9	Failed	NA	NA	NA
11	Pass	NA	NA	NA
12	Failed	NA	NA	NA
13	NA	NA	NA	NA
14	Failed	NA	NA	NA
15	Pass	NA	NA	NA
16	Failed	NA	NA	NA
17	Pass	NA	NA	NA
18	Pass	NA	NA	NA
19	Pass	NA	NA	NA
20	Failed	NA	NA	NA

SN M3

Pins	50V	100V	200V	300V
1	Pass	Pass	Pass	Failed
2	Pass	Pass	Pass	Pass
3	Pass	Pass	Pass	Failed
4	Pass	Pass	Pass	Failed
5	Pass	Pass	Pass	Failed
6	Pass	Pass	Pass	Failed
7	Pass	Pass	Pass	Failed
8	Pass	Pass	Pass	Failed
9	Pass	Pass	Pass	Failed
11	Pass	Pass	Pass	Pass
12	Pass	Pass	Pass	Pass
13	Pass	Pass	Pass	Pass
14	Pass	Pass	Pass	Pass
15	Pass	Pass	Pass	Pass
16	Pass	Pass	Pass	Pass
17	Pass	Pass	Pass	Pass
18	Pass	Pass	Pass	Pass
19	Pass	Pass	Pass	Pass
20	Pass	Pass	Pass	Pass

Standards Update - Crystal Oscillators

- **Crystal Oscillators (Martinez, GWG, DLA-VA)**

- **Background**

- ❖ During the DLA audits of crystal oscillator suppliers, we found that no one was buying QPL Class S oscillators. Instead, the manufacturers were selling catalog parts to their own “Class S-like” flow.
- ❖ Simply stated, the specification MIL-PRF-55310 was out of date and needed a lot of work.
- ❖ DLA lead auditor at the time made presentation in CE-12 Space Subcommittee meeting chaired by NASA.
- ❖ NEPAG GWG group worked with DLA to revise the specification (Y. Afroz of DLA-VA worked very diligently to make it happen)

- ***Return on investment for NASA flight projects***

- ❖ ***NASA is in a unique position to lead the community in updating requirements for the use of crystal oscillators in space.***

- **FY19:** NASA worked with DLA and other organizations to update MIL-PRF-55310, the current released version is Rev. F.
- **FY20:** Supported the Aerospace proposed amendment. This Amendment has manufacturers buy-in. It has been released.
- **Impact of coronavirus: None**

Analog to Digital Converter BoK

- **A/D BoK (N. Ovee, F. Irom)**

- **Background**

- ❖ The last NASA A/D selection guide was published by S. Agarwal in 2005
- ❖ Many new products have since become available for NASA applications.
- ❖ This effort is to update the document.

- ***Return on investment for NASA flight projects***

- ❖ ***The updated guide would be a resource for NASA designers of Analog-to-Digital converters.***

- **FY19:** We collected information during L@L Webinars but due to resources limitation (flight projects had priority), the guide could not get started.

- **FY20 Status:** The number of A/D and D/A products has proliferated in the last 15 years, (close to 1000 counting standard and non-standard parts). Therefore, this task was broken down into phases. The first phase was the radiation aspect of standard A/D and D/A devices. This phase was completed and the document delivered to the HQ. This was a NEPAG supported telework task. Rest of the work was put on hold.

- **Impact of coronavirus: None.**

Connectors

- **Connectors (Billig, Gutierrez as backup)**

- **Background**

- ❖ Connectors have had many problems
- ❖ M. Sampson in late 2019 asked that a small task be opened to
 - Have NASA presence in some of the prime conferences
 - Support DLA audits of widely used connector suppliers
- ❖ JPL Wire, Cable and Connector specialist Ray Billig was asked to provide support. Tony Gutierrez was designated as his back-up.

- ***Return on investment for NASA flight projects***

- ❖ ***NASA to help provide solutions to the nagging issues with connectors.***

- **FY19:** (a) Participated in a DLA audit.

- **FY20:** (a) Presented at a conference. (b) supported all NASA meeting on wires and connectors.

- **FY21: On hold**

- **Impact of coronavirus: Yes – no audits, no technical meetings.**

<http://nepp.nasa.gov>



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